Date: 1st October 2021
Our Ref No.: TJ/UT1/OUT-10

To,
Doosan Heavy Industries & Construction Co., Ltd.
Mr. Youngsoo Son– Project Manager
465 Gangnam-daero, Seocho-gu, Seoul, Korea (06611)

Contract Reference: Engineering, Procurement and Construction Contract between Nepal Water And Energy Development Company Private Limited (NWEDC) and Doosan Heavy Industries & Construction Co. Ltd for the Engineering, Procurement and Construction (EPC) for the 216 MW Hydropower Plant at Upper Trishuli -1, Nepal

Subject: Submission of Review Notes on Surrounding Rock Stability Calculation of Adit No. 3 and Excavation and Initial Support Drawings of Adit No. 3

References:
1. Document No.: UT1-C-150-CVL-DC-43002, Rev. B dated 20th September 2021
2. Drawing No.: UT1-C-150-CVL-DG-43004, Rev. C dated 20th September 2021

Dear Sir,

Reference is made to the above No.1 and 2 including attachments, received with transmittal No. UT1-HEP-DHI-D-0052 dated 20th September 2021, regarding. surrounding rock stability calculation of adit no. 3 and excavation and initial support drawings of adit no. 3.

Please find our comments and replies in the Review Notes (RN-0014, RN-0015, RN-0016, and RN-0017) enclosed herewith this letter.

Sincerely,

.....
Mr. Carsten GUNTERMANN
Project Manager (CRE)

Tractebel TRACTEBEL ENGIE Engineering GmbH

Enclosure:
1. Review Notes (RN-0014, RN-0015, RN-0016, and RN-0017)

UPPER TRISHULI-1 HEP (216MW)

Client	**Nepal Water and Energy Development Company Private Limited**
Owner's Engineer	**Tractebel Engineering GmbH / Jade Consult**

REVIEW NOTE

Contractor	**Doosan Heavy Industries & Construction Co., Ltd.**		
Title of the Document	Excavation and Initial Support Drawing of Adit No. 3		
Document No.	UT1-C-150-CVL-DG-43004 (4 sheets)	Revision	C
Date of Documents	10.09.2021	Received Date	20.09.2021
Transmittal Form No.	UT1-HEP-DHI-D-0052		
Previous Review Date/Status	16.08.2021/RR	Prev. Review Note No.	RN-0005.
Review Note No.	**RN-0016**	**Present Review Date**	**30.09.2021**
		Present Review Status	**RR**

A: Approved AC: Approved with Comments RR: Returned for Resubmission

General Comment

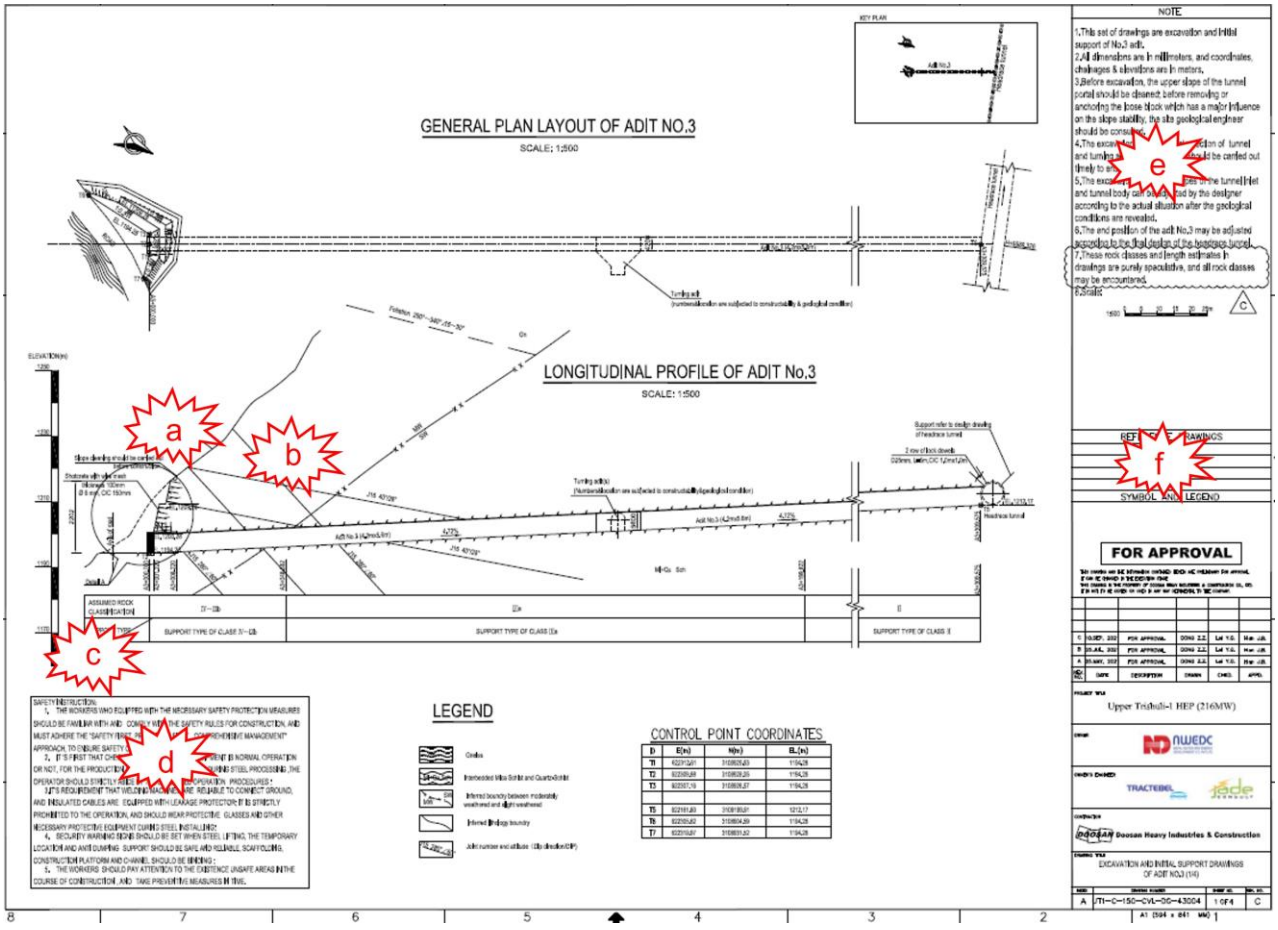
With the Review Notes Nos. 0010 and 0011, dated 20.09.2021, we have addressed the layout and support drawings for the Investigation Tunnel to the Powerhouse. These drawings were dated 19.08.2021 and they were submitted to us by 01.09.2021. The newly submitted drawings for Adit No. 3 are dated 10. September 2021 and were submitted to us on 20.09.2021. Both sets of drawings (for the Investigation Tunnel and for the Adit No. 3) are of the same status. For this reason, several comments of review notes Nos. 0010 and 0011 had to be repeated in the Review Note at hand.

Monitoring shall also be addressed on the drawings. Typical arrangements of sections with number of optical targets, distance between monitoring sections for each rock class, distance between tunnel face and installation of monitoring section, and type of target shall also be addressed.

The sections of the tunnel shall show also the arrangement of the supply lines (fresh air, water, wastewater, electricity, compressed air) so that the clearance during construction is evident.

UT1-C-150-CVL-DG-43004 (sheet 1/4)

The following comments refer to the markings in the drawing:


GENERAL PLAN LAYOUT OF ADIT NO.3
SCALE: 1:500
LONGITUDINAL PROFILE OF ADIT No.3
SCALE: 1:500
a
b
c
d
e
f
LEGEND
CONTROL POINT COORDINATES
NOTE
1.This set of drawings are excavation and initial support of No.3 adit.
2.All dimensions are in millimeters, and coordinates, chainages & elevations are in meters.
3.Before excavation, the upper slope of the tunnel portal should be cleared, before removing or anchoring the loose block which has a major influence on the slope stability, the site geological engineer should be consulted.
4.The excavation span at the intersection of tunnel and turning adit is large, support should be carried out timely to ensure safety.
5.The excavation and support types of the tunnel inlet and tunnel body can be adjusted by the designer according to the actual situation after the geological conditions are revealed.
6.The end position of the adit No.3 may be adjusted according to the final design of the headrace tunnel.
7.These rock classes and length estimates in drawings are purely speculative, and all rock classes may be encountered.
8.Scale:
FOR APPROVAL
Upper Trishuli-1 HEP (216MW)
EXCAVATION AND INITIAL SUPPORT DRAWINGS OF ADIT NO.3 (1/4)
A | UT1-C-150-CVL-DG-43004 | 1 OF 4 | C

a) Details at the portal must not necessarily be shown.

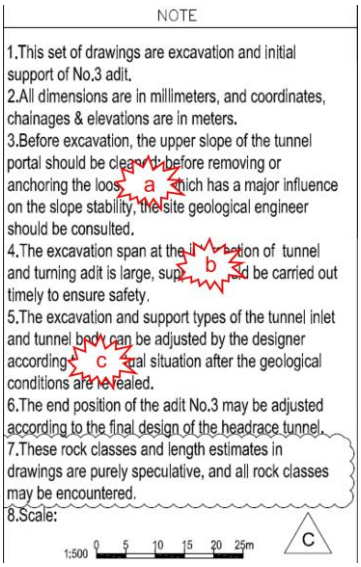
b) Geological structures must not be indicated in this drawing. A small table of major joints sets is sufficient.

c) Provide one row with “Overburden Thickness” (= rock cover thickness).

d) Safety instructions are not needed on a layout drawing. Delete. They should appear in the Method Statement for the tunnel.

e) See separate notes below.

f) Provide the reference drawings/documents in this list.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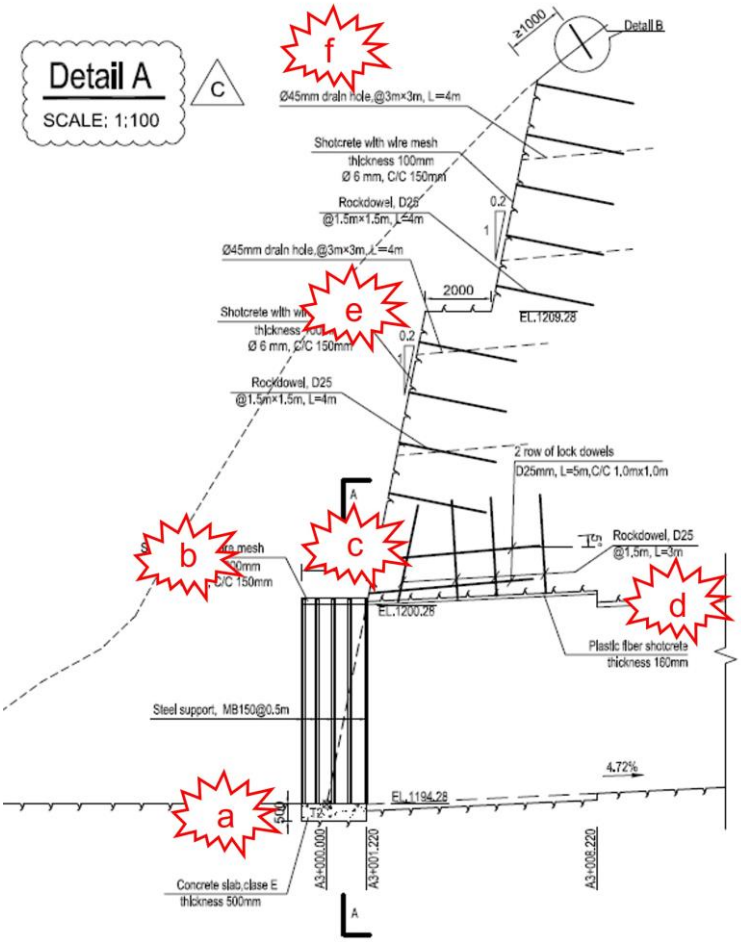
6.The end position of the adit No.3 may be adjusted according to the final design of the headrace tunnel.
7.These rock classes and length estimates in drawings are purely speculative, and all rock classes may be encountered.
8.Scale:
1:500 0 5 10 15 20 25m
C

a) Delete this comment. It is related to construction and not to layout. Such comment should appear in the Method Statement or on construction drawings of the portal cut.

b) Same as under a).

c) Modify this comment: The Designer shall provide alternatives and options in the tunnel support design, so that the support can be adjusted in case geological conditions are varying.

UT1-C-150-CVL-DG-43004 (sheet 2/4)



a) At the portal, a concrete invert with a thickness of 500 mm is unnecessary for a temporary tunnel. Revise.

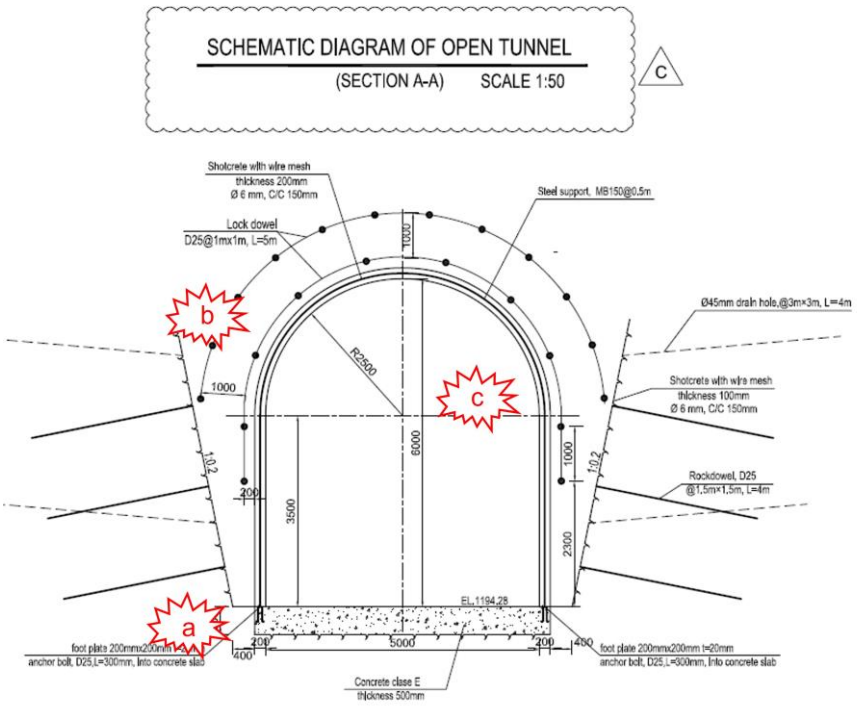
b) 5 Steel ribs at spacing 500 mm appear very heavy. In total three ribs at 1.0 m spacing and a steel sheet (5 mm) in the vault of the ribs are reasonable protection from rock fall. Consider and revise.

c) Steel support is generally required at the portal and for the first meters (steel ribs or lattice girder). The spiles shall stick out by 300 mm and a stell rib needs to be placed underneath the spiles. The sticking out spiles need to be fully embedded in fibre reinforced shotcrete.

d) Indicate dowels in the tunnel.

e) The bench is not required. This reduces excavation volume and also the height of the slope (by several meters).

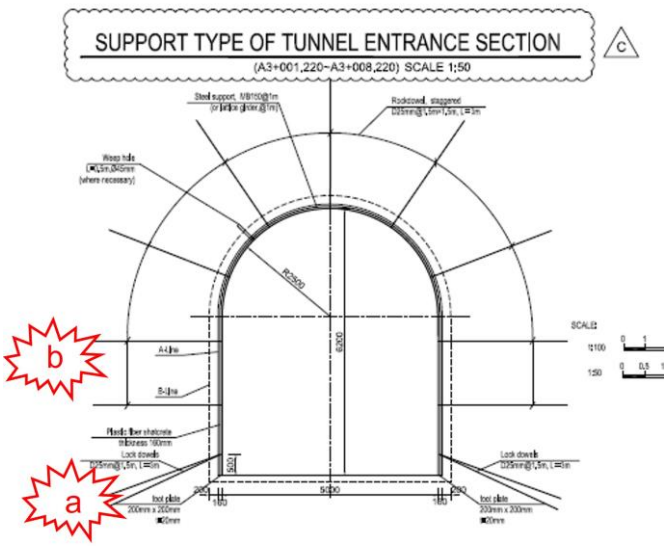
f) Drain holes shall be provided with perforated PVC-pipe, wrapped in geotextile. Rock mass is expected to be weathered and contains many fines. The perimeter above the slope cut may be unnecessary, but a cross drain installed 2 m above the portal roof is required.



a) lateral space between the concrete liner and the rock slope of only 400 mm appears to be in practice too small. Revise. After the steel rib is installed, the shown “anchor bolts” in the concrete slab or in rock cannot be drilled as shown, check practical feasibility.

b) Second row only indicative, 300 mm out of first row of spiles (= dowels), and staggered arrangement. Spacing of spiles shall be 400 mm as in the inner row.

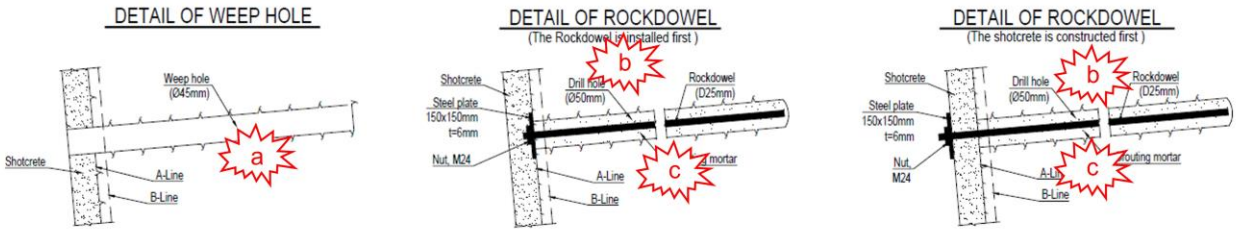
c) Shadow the area that is reinforced concrete and indicate the area that is covered with 300 mm shotcrete.



a) "Lock dowels" should be indicative, only. As generally no or little lateral rock pressure is acting at portals.
b) Incline dowels in sidewalls at 10° downward.

UT1-C-150-CVL-DG-43004 (sheet 3/4)

The size of the turning bay appears to be very large. Countercheck with size of trucks used for mucking. Consider that the turning bay is only used for the purpose of mucking, and only until the Headrace Tunnel is reached. Indicate for which rock class the suggested rock support is valid. Incline dowels in sidewalls 10° downward.



a) It shall be noted that weep holes require the insertion of a perforated PVC-pipe (wrapped with geotextile) for weathered rock (containing large number of fines).
b) Spacers, and their distance to each other, fixed on the steel bar shall be shown. They are necessary to keep the steel bar in the centre of the borehole to fully embed it in grout and consequently protect it from corrosion.
c) Generally, dowels are not installed using grout mortar (= sand + water + cement) as indicated, but with cement grout (= water + cement). The water/cement ratio (w/c) needs to be indicated in the drawing or the notes of the drawing. Experience shows that for dowels in slopes and in tunnel sidewalls, which are drilled at an angle of 10° downward, a water-cement ratio of 0.50-0.60 (max.) is the optimum as the grout flows into the borehole and fills it. In the tunnel roof, however, such w/c-ratio is far too high, and one will have always difficulty to fully embed the dowel in grout. A w/c-ratio of 0.30, i.e., a cement paste rather than a liquid needs to be used. Only with such low w/c-ratio dowels of reasonable bond strength over the entire length of the dowel can be achieved.

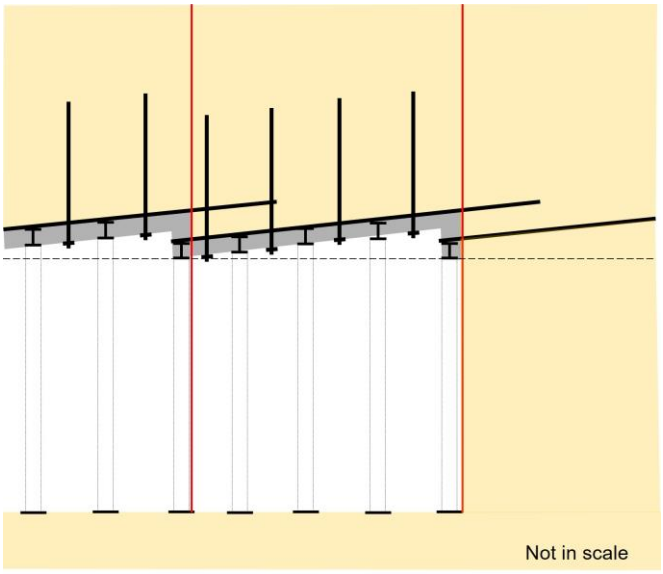
UT1-C-150-CVL-DG-43004 (sheet 4/4)

It is noted that a concrete lining for Class IV and Class V is omitted, which is reasonable for a temporary tunnel.

The drawings of the tunnel section for different rock/support classes are in general acceptable. Few issues such as indication of Q-value for each class and free unsupported span as discussed during the online conference of 31. August 2021 needs to be added. Furthermore, the dowels in the sidewalls of all profiles

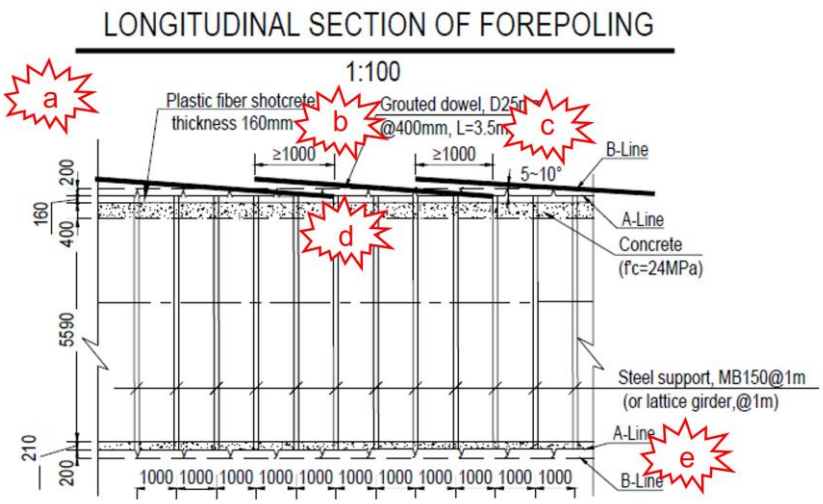
need to be inclined at 10° downward. Only above the springline, dowels shall be installed perpendicular to the tunnel perimeter.

The longitudinal section of forepoling with spiles (= dowels) as shown on the drawing is practically not feasible to construct and it is statically not stable.



This sketch demonstrates schematically and in principle driving of a tunnel by fore-poling with spiles (dowels), which is practically feasible. The red lines indicate the location of the tunnel face, when new spiles (dowels) are installed. For tunnels smaller than 10 m in diameter the most economic and safe set-up is as follows: the length of spiles should be 6.0 m. The overlap of subsequent rows of spiles should be 1.7 m. The look-out angle of spiles should be 4°, only. 6.0 m long dowels still allow directional drilling to create a canopy. This length of spiles also allows reasonable distances between faces where spile installation is required. Note that installation of spiles is very time-consuming. In addition, this geometrical set-up allows to place under the newly installed spiles, which are sticking out (protruding) 300 mm, a supporting steel rib, which is then embedded in shotcrete. This is the same statical principle as applied at tunnel portals. Furthermore, this set-up allows grouting in-between the spiles (dowels).

It is noted that rib spacing shall be 1.0 m and the steel ribs are of different sizes. Dowels in the sidewalls and in the roof shall be at a spacing of 1.0 m. This needs to be clarified during the design and the geometry of the individual ribs needs to be shown on the construction drawings.



a) Modify generally the drawing as suggested above or similar. Tunnel driving direction always from left to right.
b) Indicate rock dowels that are installed in the roof.
c) Indicate weep holes.
d) Clearly define out-look angle and overlap of spiles
e) Indicate longitudinal steel bar connections between ribs. Number the steel ribs as they have different size. (e.g. 1,2,3,4,1,2…)

Dr. Ulrich Glawe

(Signature)